



United States Department of the Interior

BUREAU OF LAND MANAGEMENT  
Salt Lake District Office  
2370 South 2300 West  
Salt Lake City, Utah 84119

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JUL 26 1993

Air Quality

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7000  
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JUL 26 1993

Dr. Dianne Nielson  
Director, Utah Department of Environmental Quality  
168 North 1950 West  
P.O. Box 144810  
Salt Lake City, Utah 84114-4810

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JUL 27 1993

Utah Dept. Environmental Quality  
Executive Director's Office

Dear Dianne,

The next meeting of the Technical Review Committee is scheduled for July 28, 1993 at 9:00 am. I have enclosed a draft agenda for this meeting together with the quarterly status report of the U.S.G.S. I am sorry that the quarterly report is a bit late. This will be the last meeting of the TRC before the end of the data collection phase of the study. I look forward to seeing you at the meeting.

Sincerely,

*for* Deane H. Zeller  
District Manager

Enclosures:  
As Stated Above

PROPOSED AGENDA  
TECHNICAL REVIEW COMMITTEE MEETING  
JULY 28, 1993

9:00 am            Preliminary Meeting

- Review of Minutes
- Discuss Progress Report
- Other Business

9:30 am            Main Meeting

- Progress Report:    Jim Mason
- Progress Report:    Ken Kipp

11:30 am           Post Meeting

12:00 noon        Adjourn

## **PROGRESS AND PLANS FOR THE BONNEVILLE SALT FLATS STUDY, MAY THROUGH JULY, 1993**

July 28, 1993

### **Progress:**

Water-level measurements were completed in Pilot Valley during the week of May 17-21 and on the Bonneville Salt Flats during the week of May 24-28. Almost all the wells were measured except some wells that are located south of I-80. The depth of the surface pond in this area prevented the measurement of these wells. In a continuing effort to monitor salt dissolution and precipitation, the distance from the top of the casing to the ground surface was measured at the same time as the water-level measurement at each well. This same process will be an integral part of the water-level measurements taken in July.

Ten additional shallow wells were hand augured on the Bonneville Salt Flats (see figure). Seven of the wells are located along the western margin in order to ascertain the significance of the apparent hydraulic gradient to the northwest away from the salt crust. Two wells in the farthest north of three separate lines have been instrumented with pressure transducers and data loggers. One of the instrumented wells is located in the vegetation zone adjacent to the weather station and the other instrumented well is located on the mud flats to the southeast. The instrumentation has been in place since mid-May. The data-storage modules have been retrieved from the data loggers and hopefully, the data can be presented at the meeting.

Three of the hand-augured wells are located adjacent to existing deeper wells in the north line that extends from the salt crust to the collection ditch. These wells were completed at a shallower depth than the adjacent wells. Samples will be collected from the new wells and analyzed for tritium. The new tritium values will be compared to the values obtained from the deeper wells. From these data, some insight might be gained as to the flow mechanics toward the collection ditch.

Changes in the distance from the top of the casing to the ground surface at observation wells for the March/April water-level measurement period have been plotted and contoured using ARC/INFO, a geographic information system software package. The volume of salt dissolved can be estimated using this software. From this estimate, the amount of water needed to dissolve this volume of salt can be estimated. The majority of this water came from south of I-80 with a density of about 1.04. Once this volume is determined, then the amount of salt transported onto the salt crust can be estimated. These estimates will be refined using satellite imagery and precipitation data obtained from the weather stations located on the Bonneville Salt Flats.

Two satellite-image scenes have been ordered. The scene from the fall of 1992 will be used initially to outline the extent of the salt crust. This outline will be used to define the area from which salt could be dissolved during the past winter. The second scene is from early spring and will show what is considered to be the maximum extent of the surface pond. A third scene from this summer will be used to show the maximum extent of the new salt crust. These scenes will be examined using spectral responses in Thematic Mapper bands 1-7 to determine spatial and temporal variations in the salt crust and, if possible, the shallow-brine aquifer. If time and money are available, any applicable methods of analysis developed for 1992-93 will be applied to determine changes in the salt crust during the winter of 1991-92, which would be considered more representative of normal years.

Extensive sampling of water from shallow wells has been completed in both Pilot Valley and the Bonneville Salt Flats during the period from May into July. More than thirty samples were collected from shallow wells on the Bonneville Salt Flats. Most of the wells sampled had been sampled in August, 1992. The new data will be compared to the analyses from 1992 to determine the possible effects of the winter surface pond on the shallow-brine aquifer and the possible depletion of potassium in relation to the late summer concentration. In most cases, the samples were collected soon after the surface pond disappeared from the vicinity of the well. This requirement insured that the sample was truly representative of the shallow-brine aquifer and not mixed with any surface water as a result of downward leakage from pumping. Samples were also collected from wells along the western margin of the Bonneville Salt Flats beyond the areal extent of the surface pond. The analyses from these wells will probably show no change in the potassium concentration. Four samples were collected in late May from the surface pond and nest of shallow wells adjacent to the weather station on the salt crust. Major-ion and deuterium and oxygen-18 analyses were requested on these samples with the intent of determining the extent of any vertical circulation of pond water. Oxygen-18 analysis was requested on several other samples for the determination of possible vertical circulation throughout the Bonneville Salt Flats.

Trends in major-ion chemistry were examined in long-term data from wells on the Bonneville Salt Flats. Data from Turk's reports were used along with data from the USGS database. The data from samples collected in May, 1981, indicate a possible depletion in potassium. Data from August, 1992, indicate that the potassium concentration is virtually the same as in the mid-1960s. A chemical analysis of water collected from the surface pond in January, 1993, shows a noticeable depletion in potassium relative to sodium. The noticeable depletion of potassium in the data from 1981 might be the result of infiltration of winter surface pond water into the shallow-brine aquifer. New data obtained from the recently collected samples might answer this question.

Through consultation with Blair Jones, USGS Research Hydrologist in Reston, a line of evidence to support a dual-porosity system in the shallow-brine aquifer has been developed. The Cl/Br ratios in the pore fluids obtained from cores is similar to what Blair has found Great Salt Lake cores. The Cl/Br ratios from shallow Bonneville Salt Flats cores tend to be in the vicinity of 1500. The Cl/Br ratios from water taken from shallow wells tend to be about two times larger. The chloride concentrations are similar in both the pore fluids and well fluids, and only the bromide is depleted in the well fluids. The well fluids are more mobile than the pore fluids and thus, indicating transport of salt in the fractures of the shallow-brine aquifer. This difference might be indicative of a system where the bromide is being removed with slow or no replacement whereas the chloride is being replaced readily. Cl/Br ratios will be determined for the recently collected samples and compared to the data obtained from the samples collected in August, 1992.

A possible working hypothesis to explain a seasonal variation in potassium concentration in the brine obtained from wells might involve dilution by a potassium-depleted winter surface pond and then a subsequent influx of potassium from pore fluids by diffusion. Questions arising from this hypothesis would include: 1) What is the continuing source of the potassium in the pore fluids?; and 2) What is the rate by which potassium diffuses from the pore fluids to the more mobile fracture fluids?

Twelve samples were collected in Pilot Valley of which six samples were from wells installed by Lines. These wells will be sampled again at the end of August and the two sets of chemical analyses will be compared to see if similar trends exist in Pilot Valley as on the Bonneville Salt Flats. These trends include seasonal changes in potassium concentrations and Cl/Br ratios in pore fluids and well fluids.

Recent modeling efforts have included initial development of a cross-sectional model to a depth of 700 feet and sensitivity analysis of the original shallow cross-sectional model. The deep cross-sectional model will be used to examine deeper circulation patterns on the western basin margin and beneath the shallow-brine aquifer. Initial computer simulations have resulted in nonconvergence with time. This is thought to be the result of large density contrasts. This problem will need to be addressed in the calibration process. This deeper cross-sectional model is planned to be incorporated in the final report along with a detailed areal model of the shallow-brine aquifer.

Simulations using the shallow cross-sectional model had similar problems with nonconvergence resulting from large density contrasts. These simulations are being undertaken to examine the sensitivity of computed inflow to the collection ditch as related to its depth of penetration into the shallow-brine aquifer. If this relation proves to be very sensitive, then a more accurate measurement of ditch depth will be obtained.

**Plans for the next quarter:**

Water levels will be measured in the beginning of August and the end of September. During the August measurement period, the distance from the top of well casing to the ground surface will be measured for estimating salt accumulation. If new salt crust is thin, such as in areas where the salt crust did not exist last year, the salt thickness will be measured.

Collect samples from representative wells on the Bonneville Salt Flats for tritium analysis. These analyses will be used to delineate area of possible upward leakage if the determined values are less than values for present precipitation. Tritium samples will be collected from the three new wells along north line between salt crust and collection ditch. These tritium values will be compared to others determined previously. Also, samples will be collected for tritium analysis from representative nested wells completed in alluvial-fan aquifer. These analyses will be used to support or disprove the hypothesis that direct recharge to the alluvial-fan aquifer occurs through large fractures at land surface.

Collect samples for analysis from the five 63-foot wells drilled in October, 1992, on the Bonneville Salt Flats. Major-ion and deuterium and oxygen-18 analyses will be requested for these samples.

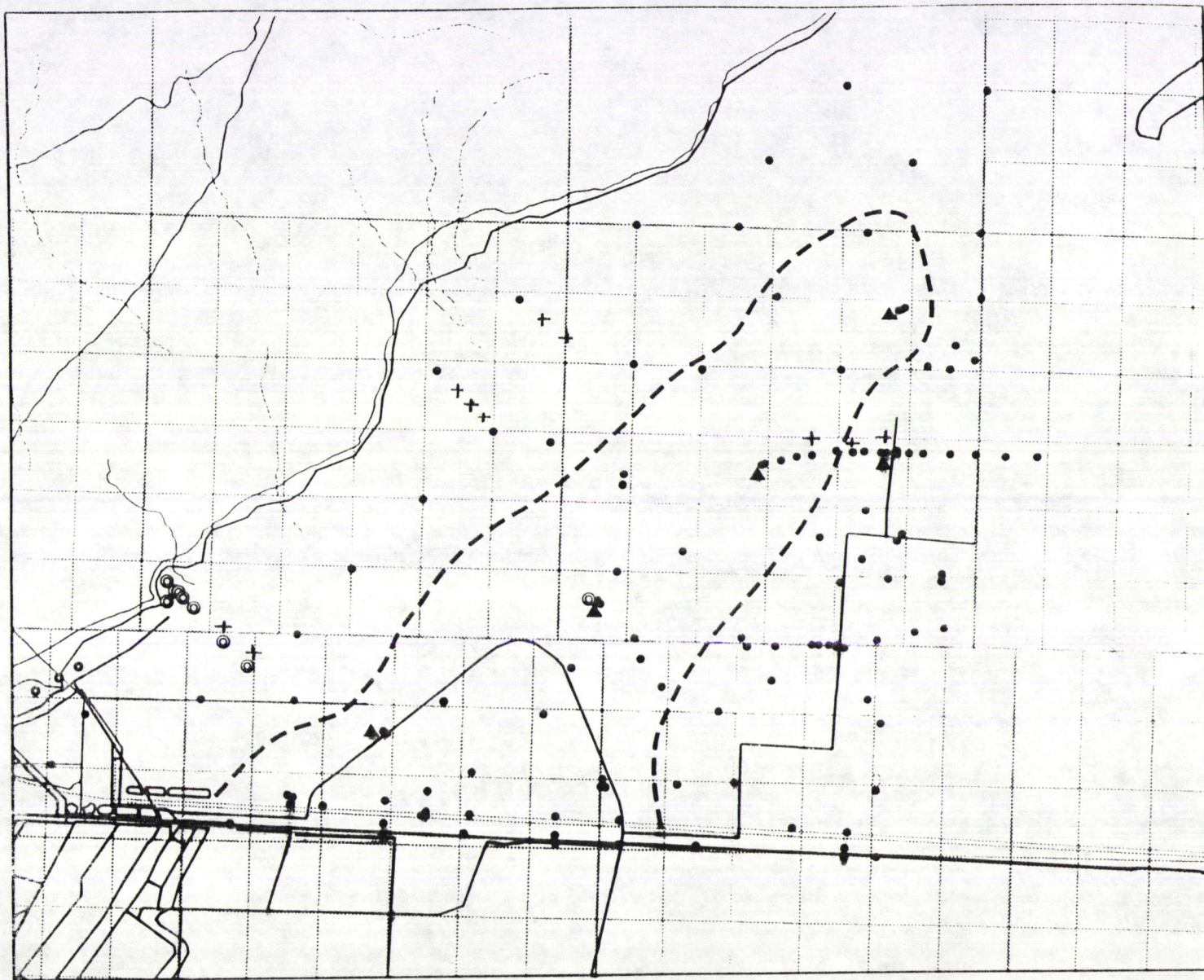
Collect samples from same wells sampled earlier in Pilot Valley. These samples will be collected in early September to maximize length of time between samples and to get them to the USGS lab before fiscal year deadline.

Examine the density profile in the deep nested wells completed beneath the salt crust. This information will be used to help determine the vertical gradient at depth beneath the salt crust

Continue refinement of salt dissolution and accumulation estimates for the past year using satellite imagery and ARC/INFO software.

Compile water-level data for data sets when final elevation data is available from BLM. The final survey is scheduled for the third week in August. If possible, elevation data should be obtained for wells presently being monitored in Pilot Valley.

Continue development of deep cross-sectional model and detailed areal model of the shallow-brine aquifer.



+ - Hand-auged wells, May-July, 1993

▲ - 63-foot wells, October, 1992

⊙ - Deep, nested piezometers

0 4 8 MILES  
4 4 8 KILOMETERS

Hydrologic data sites - locations approximate

Subject: PROGRAMS and PLANS\ (Bonneville Salt Flats Study, Utah District  
Quarterly Report Contribution, May-July 1993

From: Ken Kipp

I read several papers and journal articles pertinent to this study. One was about solute transport processes in saturated clay. The authors considered seven mechanisms of solute transport under low permeability conditions. They did some parameter estimation and sensitivity analyses to show that a surface diffusion mechanism of sorbed solute seems to give transport fluxes that are as large as any other transport flux.

Another article was about data requirements for groundwater contaminant transport modeling. From their synthetic test case study, the authors concluded that 4 years of data was much better than 2 years for determining system transmissivity and dispersivity parameters and predictions, that transmissivity distributions interpolated from point estimates were much less accurate than parameter identification procedures using head and concentration data, and that significant errors in transport prediction occurred when calibration data were limited to two years and 12 wells.

An article on the modeling of brine transport discussed modifications to the transport equations, boundary conditions, and numerical methods needed to properly handle dense saline brines. The authors considered a density flow component to Darcy's law and a pressure diffusion component to Fick's law. If the coefficient of density flow is greater than the order of molecular diffusivity, then the density flow mechanism is significant. The pressure diffusion coefficient has units of time and must be less than a few nanoseconds for pressure diffusion to be negligible. Unfortunately, these coefficients have never been evaluated for most aquifer materials. They present some generalized boundary conditions considering these additional transport mechanisms. Of the numerical schemes they examined, the quasi-linearization of the equations using new dependent variables, followed by sequential solution was the most successful for brine systems. The HST code uses sequential solution also.

The last article I read was also about the transport equations for saline brines. The authors determined that equations of the same form as used in the HST code were valid provided that there was no density flow component of Darcy flux. This means that gradients of concentration must be small enough to be neglected at the dispersion length scale. It is not clear to me that this is true in general. Further study is necessary. They also gave equations for density and viscosity as a function of solute concentration, which they compare to handbook data for saline solutions.

This quarter I worked with two cross-sectional models. One was an extension of the earlier model traversing the ditches on the east side of the study site. The other was a new model traversing the site from northwest to southeast.

The east side model was extended to cover both arms of the production ditch and go about one mile east of the eastmost ditch branch (Fig.1). The purpose of the work with this model was to evaluate the sensitivity of the flow field and production rate of the ditches to their cross-sectional dimensions. Four cases were run with ditch depth and width values of 10 ft x 10 ft, 15 ft x 10 ft, 20 ft x 10 ft, and 20 ft x 20

ft. Each simulation took about 30 minutes to execute. Problems were encountered with the variable density model so a constant density model was used. The results showed almost no change in ditch production rates as the dimensions were varied. This is probably due to the high vertical permeability which allowed hydrostatic pressure distributions to be established below the ditches. Replacing porous media with hydrostatic conditions by deeper ditches which had hydrostatic boundary conditions along their perimeters caused little change in the flow field.

Total net fluid flow rates into the ditches varied by only 3% with the different dimensions. About 5 times more brine entered the system through the east boundary than through the west boundary. This is due to the assumed water level at the east boundary being one foot higher than the at the west boundary and about two miles closer to the nearest ditch.

A cross-sectional model extending from northwest to southeast across the study region was formulated to simulate the interaction of the alluvial fan and shallow brine and basin fill aquifers. The production ditch was included but not the plant supply wells. A sketch of the region and boundary conditions appears in Figure 2. The overall dimensions of the region are 745 ft vertical and 58000 ft horizontal. The boundary between the alluvial fan aquifer and the basin fill aquifer was approximated by a single stair step for the first model formulation. The upper boundary at the land surface was taken to be a specified precipitation flux, the lower boundary under the alluvial fan aquifer was taken to be impermeable representing bedrock. The lower boundary through the basin fill aquifer was set at specified pressure. The right hand boundary was set at leakage with a specified atmospheric pressure at the top node. The left hand boundary was taken to be impermeable. The production ditch was represented as a specified pressure node for the present time.

The finite difference mesh is shown in Figure 3. Cells above the land surface are excluded from the simulation. Figure 4 shows the aquifer parameters and b.c. values. The salt crust was taken to extend from 13000 to 39000 ft representing 3.5 miles of thick crust bounded by 0.75 miles of thin crust. The fluid viscosity was taken to be constant and the longitudinal and transverse dispersivities were set equal to a large value for ease of calculation at this time.

The objective was to run this model to steady-state to show circulation patterns and the effect of the production ditch. The first simulation was for flow only and had a pressure boundary condition under the alluvial fan aquifer. This simulation gave essentially no rise of the water table in the alluvial fan. Instead all the recharge flowed out the bottom of the alluvial fan aquifer. Then we changed the bottom b.c. to impermeable under the alluvial fan aquifer.

The initial conditions were fresh water in the alluvial fan aquifer and saline water at a mass fraction of 0.250 in the other aquifers. The approach to a steady-state solution was calculated by marching in time from the initial conditions. Because the initial conditions do not represent the system at any particular time and are quite artificial, the time to reach steady-state has no physical significance. The density and concentration contrasts of this initial condition meant that small time steps of 0.5 day were used up to 10 days. Then the model was run to 10000 days. The maximum time step had to be limited to 100 days for stability. This restriction was due to a problem in the automatic time step calculation which is still being diagnosed. Other problems include

difficulty with the outflow boundary concentration at the ditch, and at the leaky boundary. A previously identified problem with the cross-dispersive term calculation is still present. All of these problems are being investigated.

However the preliminary results are available. Convergence problems prevented the simulations from reaching steady-state. The simulation failed at 79 time steps. At this point the flow imbalance was 10% and the solute flow imbalance was 11%. Figures 5 and 6 show 3-dimensional projections of the concentration field. Some oscillations appear where fresh water exits the system and the overshoot of concentration at the ditch and leakage boundary can be seen. It appears that the recharge from the Silver Island Mountains exits the cross section at the bottom, entering the lower basin fill aquifer. This flow appears to keep the saline brine away from the alluvial fan aquifer. The boundary condition configuration and parameters selected have a strong influence on the resulting flow field.

New visualization software was installed on the Data General-530 workstation. It has 3-dimensional slicing and shading capability.

Figures will be shown at meeting.